CLAIMS

1. A method of optimizing a waveform of an electrical current applied to an electrode, comprising the steps of:

applying an electrical current to an electrode of a device;

determining a waveform of the voltage or the current of the electrical current;

representing the waveform by mathematical expressions or numbers;

measuring a function of the device associated with the application of the electrical current; and

varying the shape and frequency of the waveform to optimize the function of the device and thereby determine an optimized waveform of the electrical current to be applied to the electrode of the device;

wherein the application of the electrical current is effective to remove a sulfur contaminant from the electrode.

2. A method of optimizing a waveform of an electrical current applied to an electrode, comprising the steps of:

applying an electrical current to an electrode of a device;

determining a waveform of the voltage or the current of the electrical current;

representing the waveform by a mathematical description such as a number of points or an analytical function characterized by a number of unknown coefficients and a fixed number of known functions;

measuring a function of the device associated with the application of the electrical current;

feeding the waveform description and the measurements to an algorithm, which may be in a computer program or other calculating device including manual calculations, including an optimization routine which uses the points or coefficients as independent variables for optimizing the function of the device; and

performing the calculations to determine values of the points or coefficients which optimize the function of the device, and thereby determine an optimized waveform of the electrical current to be applied to the electrode of the device;

wherein the application of the electrical current is effective to remove a sulfur contaminant from the electrode.

3. A method according to claim 1 wherein the electrode is an anode or cathode of a fuel cell, wherein the function is a current output or a power output of the fuel cell, and wherein the optimizing of the function is optimizing the net current or the net power produced by the fuel cell.

4. A method according to claim 1 wherein the application of the electrical current is effective to remove H_2S from the electrode.

5. A method of removing a sulfur contaminant from an anode of a fuel cell, comprising:

applying an electrical current to the anode of the fuel cell; and

pulsing the voltage of the electrical current during the application, such that the overvoltage at the anode is high during the pulses, and the overvoltage at the anode is low between the pulses.

6. A method according to claim 5 wherein the method is effective to remove H_2S from the anode.

7. A method of removing a sulfur contaminant from a fuel or air stream before it enters a fuel cell, the method comprising:

applying an electrical current to the anode or cathode of an electrochemical cell located upstream of the fuel cell; and

pulsing the voltage of the electrical current during the application, such that the overvoltage at the anode or cathode is high during the pulses, and the overvoltage at the anode is low between the pulses.

8. A method of operating a fuel cell comprising:

applying an overvoltage to the anode of the fuel cell by applying a voltage to the anode with respect to a reference electrode, where the fuel contains a significant level of a sulfur contaminant; and

varying the overvoltage between a low value normally used for power production and a high value sufficiently high for cleaning the sulfur contaminant from the anode.

9. A method according to claim 9 wherein the method is effective to remove H_2S from the anode.

10. A method of operating a fuel cell comprising:

feeding a fuel to the fuel cell containing a significant level of a sulfur contaminant; and

applying an overvoltage to an electrode of the fuel cell, and varying the overvoltage between a low value normally used for power production and a high value for cleaning the sulfur contaminant from the electrode.

11. A method according to claim 10 wherein the method is effective to clean H_2S from the electrode.

12. A pulsed anode of an electrical device operating with a significant level of a sulfur contaminant using a method of optimizing a waveform of an electrical current applied to the anode, the method comprising the steps of:

applying an electrical current to the anode;

determining a waveform of the voltage or the current of the device;

representing the waveform by mathematical expressions or numbers;

taking measurements of a function of the device associated with the application of the electrical current; and

varying the shape and frequency of the waveform to optimize the function of the device and thereby determine an optimized waveform of the electrical current to be applied to the anode of the device;

wherein the application of the electrical current is effective to remove the sulfur contaminant from the electrode.

13. A pulsed anode according to claim 12 wherein the sulfur contaminant is H_2S.

14. A pulsed anode according to any previous claim in a fuel cell with a voltage boosting circuit to change the cell voltage during the sulfur contaminant oxidation pulse to a desired value.

15. A fuel cell having a pulsed electrode including an oxidation pulse, and the fuel cell having a voltage booster to change the cell voltage during the oxidation pulse to a desired level.

16. A fuel cell system comprising:

a fuel cell having a pulsed electrode and operating with a fuel containing a significant level of a sulfur contaminant; and

a fuel processor that is simplified compared to a fuel processor required when the same fuel cell is used without pulsing.

17. A fuel cell system according to claim 16 wherein the sulfur contaminant is H_2S.

18. A method of operating a fuel cell where a sulfur contaminant is cleaned from an electrode, where the fuel cell during operation has a variation in anode and/or cathode overvoltage, the method comprising feeding back a portion of the current output of the fuel cell to a control circuit to vary the voltage waveform to maintain a desired current and cleaning the contaminant.

19. A method according to claim 18 wherein the method is effective to clean $H_2S$from the electrode.

20. A method of cleaning a sulfur contaminant from an electrode of an apparatus used in an electrochemical process, in which the electrode is cleaned by oxidizing the sulfur contaminant so that another reaction can proceed on the electrode, where the apparatus during operation has a variation in electrode overvoltage, the method comprising feeding back a portion of the current output of the apparatus to vary the voltage waveform to maintain a desired current and cleaning the sulfur contaminant.

21. A method of cleaning a sulfur contaminant from an electrode of an apparatus used in an electrochemical process, in which the electrode is cleaned by oxidizing the sulfur contaminant so that another reaction can proceed on the electrode, where the apparatus during operation has a variation in electrode overvoltage, the method comprising measuring the current or voltage across the anode and cathode of the device, and utilizing that measurement as the input to a device to vary a load impedance that is in parallel or series with the useful load of the device to vary the voltage or current waveform at the electrodes to maintain a desired current and cleaning the sulfur contaminant.

22. A method according to claim 21 where the apparatus is a fuel cell.

23. A method according to claim 21 wherein the method is effective to clean $H_2S$from the electrode.

24. A method of removing a sulfur contaminant from an electrode of a fuel cell, comprising applying an electrical energy to the electrode of the fuel cell in the form of small voltage pulses to excite natural oscillations in fuel cell voltage during operation of the fuel cell, the voltage pulses being applied at the same frequency as the natural oscillations or at a frequency different from the natural oscillations.

25. A method according to claim 24 wherein the electrode is an anode and the electrical energy is an electrical current.

26. A method of removing a sulfur contaminant from an anode or cathode of a fuel cell, comprising:

applying an electrical current to the anode or cathode of the fuel cell;

pulsing the voltage of the electrical current during the application; and

controlling the pulsing with a control function to create a waveform or a frequency of the pulsing that removes the sulfur contaminant and maximizes the power output from the fuel cell.

27. A method of removing a sulfur contaminant from an anode or cathode of a fuel cell, comprising:

applying an electrical current to the anode or cathode of the fuel cell; and

pulsing the voltage of the electrical current during the application, the pulsing exciting and maintaining a natural oscillation of the fuel cell system.

28. A feedback control method of operating a fuel cell comprising applying voltage control to an anode of the fuel cell using the following algorithm:

a) determining a mathematical model that relates the instantaneous coverage of hydrogen and a sulfur contaminant to the overvoltage applied to the anode;

b) forming an observer that relates the instantaneous coverage of the hydrogen and the sulfur contaminant to the measured current of the fuel cell;

c) driving the estimated sulfur contaminant coverage to a low value by varying the overvoltage;

d) driving the estimated hydrogen coverage to a high value by varying the overvoltage; and

e) repeating steps a) through d) as necessary.

29. A feedback control method of operating a fuel cell comprising applying voltage control to an anode of the fuel cell using the following algorithm:

a) determining a mathematical model that relates the instantaneous coverage of hydrogen and a sulfur contaminant to the overvoltage applied to the anode;

b) forming an observer that relates the instantaneous coverage of the hydrogen and the sulfur contaminant to the measured current of the fuel cell;

c) prescribing a desired trajectory of the instantaneous coverage of the hydrogen and the sulfur contaminant as a function of time;

d) forming a set of mathematical relationships from steps a), b) and c) that allows the current to be measured, the overvoltage to be prescribed and the instantaneous sulfur contaminant coverage and instantaneous hydrogen coverage to be predicted;

e) driving the sulfur contaminant coverage to a low value by varying the overvoltage according to step d);

f) driving the hydrogen coverage to a high value by varying the overvoltage according to step d); and

g) repeating steps a) through f) as necessary.

30. A feedback control method of operating an electrochemical apparatus operated using a fuel containing a sulfur contaminant, the method comprising applying voltage control to an anode of the apparatus using the following algorithm:

a) determining a mathematical model that relates the instantaneous coverage of the fuel and the sulfur contaminant to the overvoltage applied to the anode;

b) forming an observer that relates the instantaneous coverage of the fuel and the sulfur contaminant to the measured current of the apparatus;

c) driving the estimated sulfur contaminant coverage to a low value by varying the overvoltage;

d) driving the estimated fuel coverage to a high value by varying the overvoltage; and

e) repeating steps a) through d) as necessary.

31. A feedback control method of operating an electrochemical apparatus operated using a fuel containing a sulfur contaminant, the method comprising applying voltage control to an anode of the apparatus using the following algorithm:

a) determining a mathematical model that relates the instantaneous coverage of the fuel and the sulfur contaminant to the overvoltage applied to the anode;

b) forming an observer that relates the instantaneous coverage of the fuel and the sulfur contaminant to the measured current of the apparatus;

c) prescribing a desired trajectory of the instantaneous coverage of the fuel and the sulfur contaminant as a function of time;

d) forming a set of mathematical relationships from steps a), b) and c) that allows the current to be measured, the overvoltage to be prescribed and the instantaneous sulfur contaminant coverage and instantaneous fuel coverage to be predicted;

e) driving the sulfur contaminant coverage to a low value by varying the overvoltage according to step d);

f) driving the fuel coverage to a high value by varying the overvoltage according to step d); and

g) repeating steps a) through f) as necessary.

32. A method according to any of the above claims wherein the fuel used contains sulfur compound impurities, and is a fuel chosen from the group comprising: hydrogen, methane, methanol, ethanol, propane, diesel, JP-8, kerosene, gasoline, naptha, coal gas, other hydrocarbon fuels, and mixtures thereof.